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On the Three Closely Related Forms of the Genus *Liobunum* (Phalangiidae, Opiliones)

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(With 25 Text-figures)

The species of the genus *Liobunum* C. L. Koch widely distribute through Europe, Asia excluding the tropical areas, and North America, etc. A large number of species have been recorded in these continents. But some of them are known to be keenly subject to a geographic variation. From Japan the occurrence of four species has been early reported, lately one of them, *Liobunum curvipalpi* Roewer has been studied in detail by the author (Suzuki '53a, b). By him the species is varied in different localities and consisting of many allopatric forms or geographic races, some of which are so differed in palpus and penis as they are regarded as separate species. Including *L. curvipalpi* five closely related species were recognized in his paper. It may be said that *L. curvipalpi* is now in the course of active speciation. On the other hand, as we can not deny the existence of a remarkable resemblance in general appearance among its forms, the taxonomic procedure of them requires a most careful investigation, though some of them were previously treated as full species.

With this aim a large number of specimens of *L. curvipalpi* and its related forms have been captured again, and the reinvestigation of morphological characters and the cytological study have been undertaken. A remarkable chromosomal difference has been ascertained among some of the related forms and the result reaffirmed the author's former conclusion. This is the reason why the present paper has been published.

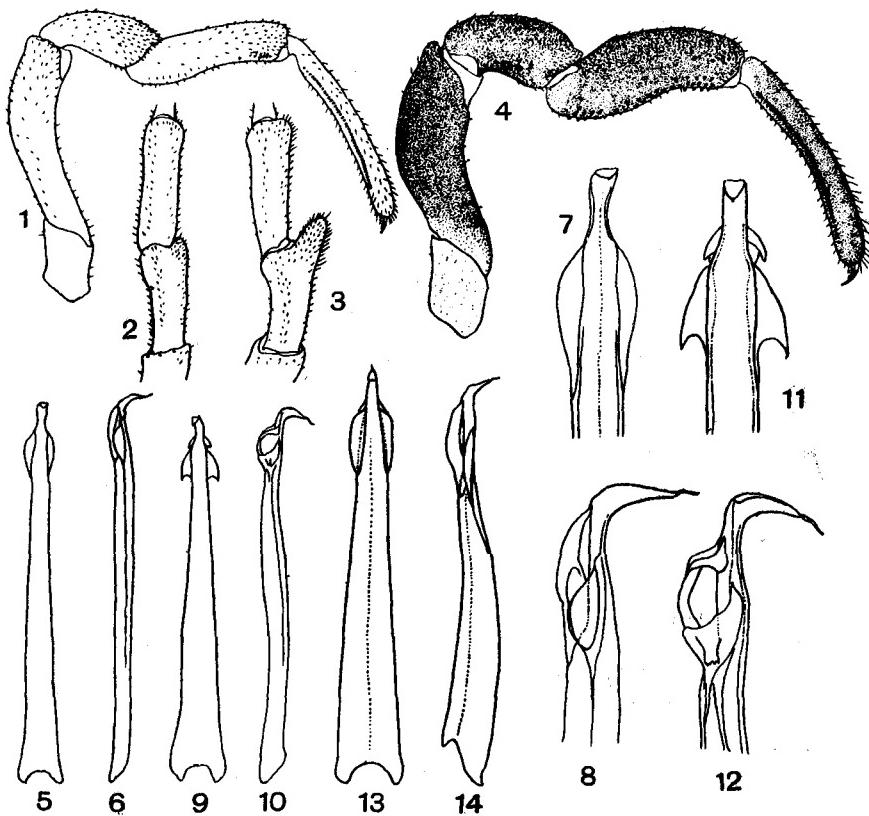
Comparison of three closely related forms, *Liobunum curvipalpi* Roewer, *L. hiraiwai* (Sato et Suzuki) and *L. tamanum* n. sp.

1. Morphology

The present statement is limited within only three forms from Mt. Hikosan (Fukuoka Pref., Kyushu Island), Chuzenji (Tochigi Pref., North Kanto District) and Mt. Bushu-mitake (Tokyo Pref.). The specimens from Chuzenji are identified as typical *Liobunum curvipalpi* Roewer, which distributed through North Kanto District and Karuizawa, etc. Those from Mt. Hikosan are recorded as *L. hiraiwai* (Sato et Suzuki), and lastly those from Mt. Bushu-mitake have not yet been made public; they are specimens of a new species *L. tamanum* described in this paper. The species was captured only at Bushu-mitake, but it is probable that it has wider distribution.

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All of these three forms are alike in their ecology, inhabiting in mountainous districts, usually found on trunks of various kinds of large trees in summer. They exhibit a remarkable similarity in general structure and coloration of bodies, and it is rather difficult to tell individual forms only by the body characters. In the measurements of their bodies and legs they present a considerable difference, but according to Weed (1892, 1893), Bishop ('49) and the writer's unpublished data such a difference cannot be regarded as a distinct specific character. On the other hand, they are characteristic of palpus and penis.



Figs. 1-3. *Liobunum tamanum* n. sp. 1, left male palpus, mesal view, 2, patella and tibia of the left palpus of the male, dorsal view, 3, the same of the female, dorsal view, $\times 20$. Fig. 4. Left male palpus of *L. curvipalpi*, mesal view, $\times 20$. Figs. 5-8. *L. tamanum* n. sp. 5-6, penis, ventral and lateral view, $\times 15$, 7-8, glans and apical portion of corpus penis, ventral and lateral view, $\times 40$. Figs. 9-12. *L. hiraiwai*, 9-10, penis, ventral and lateral view, $\times 15$, 11-12, glans and apical portion of corpus penis, ventral and lateral view, $\times 40$. Figs. 13-14. Penis of *L. curvipalpi*, ventral and lateral view, $\times 15$.

The palpus of *L. curvipalpi* males (Fig. 4) is very characteristic compared with *L. hiraiwai* and *L. tamanum* (Fig. 1); contrary to a rather normal structure in the latter two, it is very strong in the former, each of its segments is swollen and arched; particularly tibial segment is very thickened and with remarkable armaments. In *hiraiwai* and *tamanum* the tibia is only poorly armed, in particular, *tamanum* sometimes is devoid of armaments. The color of palpus is also varied among them. Although it is equally beautiful rusty yellow in *hiraiwai* and *tamanum*, that of *curvipalpi* dark brown with the exception of trochanter, which is remarkably contrasting to reddish yellow bodies. Such a distinction is so clear that at the first glance it makes us distinguish the specimens of *curvipalpi* from the other two. But the palpus of females is rather alike in structure except for the size difference, which is slender, the patella and tibia providing with a distinct apophysis (Fig. 3); the coloration is not so much characteristic of the forms as in the male. For example, in *tamanum* females captured in later season both yellowish and brownish palpi are found, though the former are more often occurred. It is thus concluded that in palpus *hiraiwai* and *tamanum* are closer to each other than *curvipalpi*.

The penis is also characteristic of the three forms (Figs. 5–14). Its size differs very much between the *curvipalpi* and the others. The corpus penis is alate near the apex and the lateral margin of the wing is smooth, evenly rounded in *curvipalpi* and *tamanum* (Figs. 5–8 and Figs. 13–14), but in *hiraiwai* its lower margin is acutely arched like a hook, terminating with a serrated process (Figs. 9–12). In this point the *hiraiwai* is most characteristic of all, the remaining two are rather close to each other except for the size difference. It is of much interest that *tamanum* is closer to *curvipalpi* than *hiraiwai* in penis, contrary to the case of palpus. Judging from these characters *tamanum* is regarded as an intermediate of *hiraiwai* and *curvipalpi*.

2. Chromosomes

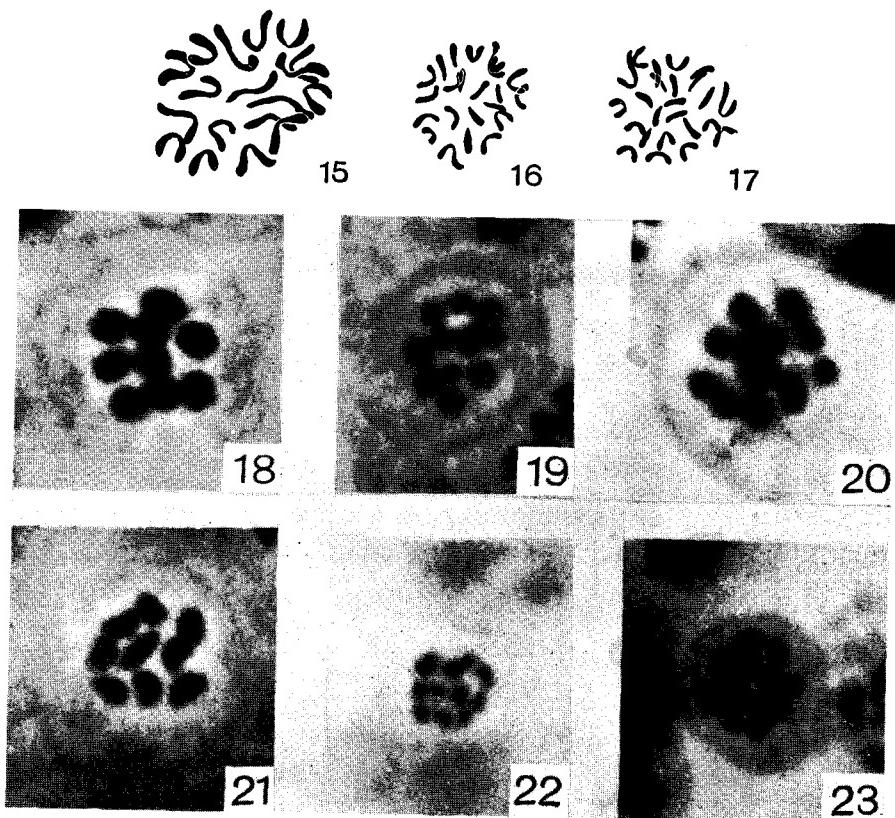
The chromosomes of Opiliones are very small in general, and it makes the preservation and observation difficult. Fortunately a considerable good slides of the three forms were obtained. All the material was fixed in fields with Flemming's weak solution.

Liobunum hiraiwai (Figs. 15, 18 and 21): In this material clear spermatogonial metaphases of both primary and secondary types were observed. The diploid number of chromosomes is always 18, all of a clear metacentric type. The larger elements show typical V- or U-shape; several pairs bearing two arms stretch with a large angle. Many are of equal arms, but others of unequal arms. In both I and II metaphases 9 elements are counted without exception. The bivalents are stout short rods to spheres. The univalents present again a V-shape.

Liobunum tamanum (Figs. 16, 19 and 22): In this slide only secondary gonia were obtained, in which $2n=22$ was clearly counted. The complement is consisted of both V- and rod-elements. Typical V- and rod-shaped ones are

regarded as to be of a metacentric and acrocentric type, respectively, but sometimes, particularly when they are small and slightly curved, it is very difficult to decide if they are metacentric or acrocentric. The complement of Fig. 16 is probably composed of 14 metacentrics and 8 acrocentrics. In both I and II metaphases 11 bivalents and univalents are always present respectively.

Liobunum curvipalpi (Figs. 17, 20 and 23) : The number of chromosomes is $2n=24$, $n=12$. As in the previous form the spermatogonial chromosomes are consisted of both metacentric and acrocentric elements. Here also no primary gonia were obtained, in the secondary gonia the elements are small in size and it



Figs. 15, 18 and 21. Chromosomes of *Liobunum hiraiwai*. 15, spermatogonial metaphase, 18 and 21, metaphases I and II. Figs. 16, 19 and 22. Chromosomes of *L. tamanum*. 16, spermatogonial metaphase, 19 and 22, metaphases I and II. Figs. 17, 20 and 23. Chromosomes of *L. curvipalpi*. 17, spermatogonial metaphase, 20 and 23, metaphases I and II. $\times 3000$.

is never easy to analyse its karyotype decidedly. In the present case, however, the complement of diploid set includes more acrocentric elements than the previous form. It seems that in Fig. 17, 12 showing V-shape and the remaining rod-shape. Both I and II metaphases possess invariably 12 elements. The chromosomes are very much resembled in shape and size to those of *L. hiraiwai*.

The number of chromosomes in the three closely related forms are $2n=18$, $n=9$ in *L. hiraiwai*; $2n=22$, $n=11$ in *L. tamanum* and $2n=24$, $n=12$ in *L. curvipalpi*; each of them showing thus characteristic chromosome number. The chromosomes of *L. hiraiwai* are all metacentrics, but those of *L. tamanum* and *L. curvipalpi* consisting of both meta- and acrocentrics. If *L. tamanum* really presents a karyotype of 14 V's plus 8 R's as suggested in Fig. 16, the number of chromosome arms in this species becomes 36, that is equal to those of *L. hiraiwai* bearing 18 V's. It seems thus 8 R's of *L. tamanum* corresponding to 4 out of 18 V's of *L. hiraiwai*. Probably 4 V's of the latter have been derived by the centric fusion between the homologous rods of four pairs in the former. Likewise the probable karyotype 12 V's plus 12 R's of *L. curvipalpi* is of much interest. But it requires further observations to give more definite conclusions.

At any rate, the three forms studied in this article are really different in chromosomal features, and here also *L. tamanum* falls intermediate between *L. curvipalpi* and *L. hiraiwai*. Basing on both cytological and morphological studies the author concludes that the two forms from Hikosan and Chuzenji and that from Bushu-mitake, respectively, are separate species. A similar condition is found also in other Opiliones such as *Gagrellula ferruginea* (Loman) and its related forms (Suzuki '56 and unpublished data). It must be emphasized that chromosomes are of much significance in the taxonomic study of closely related forms or species of some Opiliones.

In addition to the above-mentioned statement, the description of a new species, *Liobunum tamanum* will be given below.

Liobunum tamanum n. sp.

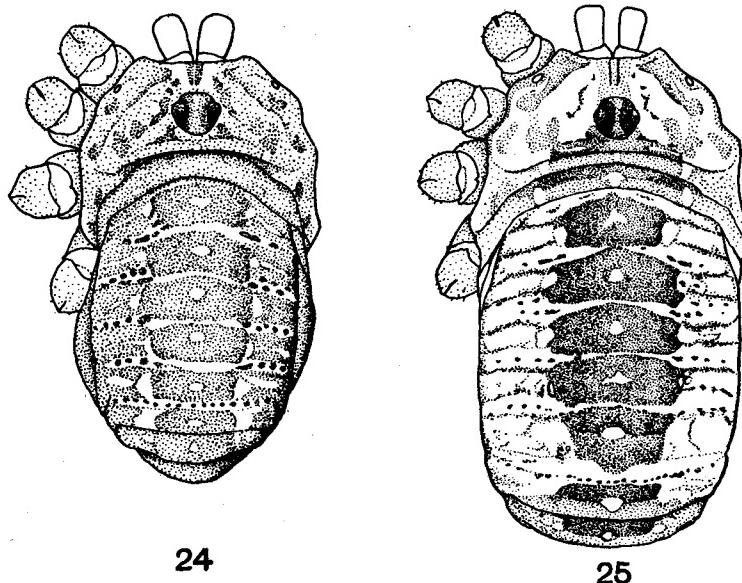
Male

Dorsum (Fig. 24) very finely granular, moderately hardened; openings of scent glands small, oval, directed upward opposite base of first trochanters; eye-tuberle nearly circular to ellipsoid from above, shallowly canaliculate and the carinae armed with fine hairs, sometimes with a few low tubercles.

Venter: Coxae and genital operculum finely granular and with scattered light hairs; sternites smooth or finely granular, armed with light hairs; coxae I to II armed with a row of fine teeth along anterior and posterior margins, coxae III to IV with an incomplete row posteriorly, rarely coxa III with a very few incomplete teeth anteriorly; trochanter of legs with small denticles, femora with many small, sharp-pointed denticles, other segments nearly smooth.

Palpus (Figs. 1-2): Femur of palpus from above slightly widened distally, from the side arched above, no armaments, with only scattered light hairs, patella short, widened distally and provided on the disto-mesal side with a small but

distinct apophysis, above with a row of hairs, apophysis with many hairs, in some, laterally with a very few teeth, tibia from above with the sides straight, from the side slightly curved, the ventral side at base somewhat swollen and distally, on the ventro-mesal side armed with a cluster of black denticles, the number of which variable in specimens, ranging between 2-3 and about 10, in some, with no denticles there, tarsus slender, slightly curved ventrally and armed ventro-mesally with a single row of small black teeth : tarsal claw with a few fine teeth at middle and base below.



24

25

Figs. 24-25. *Liobunum tamanum* n. sp. 24, dorsal body surface of the male, 25, the same of the female, $\times 10$.

Chelicera: Normal, I and II segments covered with scattered hairs, I segment disto-mesally, at base of chela with several dark brown denticles.

Coloration: Above beautiful rusty yellow with slightly darker mottlings forming irregular patches on the carapace. The sutures between segments of the abdomen narrowly silvery white, within such patches present transverse lines of slightly dark dots, sometimes interrupted mesally. The last two thorax segments and 1 to 6, in some, 7 segments of abdomen each present laterally a pair of silvery white markings, by which median band of abdomen very poorly defined, at the centre of each segment with a round silvery white spot, the median band narrowest at the posterior margin of the first abdominal segment and extending to the sixth or seventh segment. Eye-tubercle black around eyes, rusty yellow on the front and the base, silvery yellow along the groove. Chelicerae

and palpi rusty yellow. Venter slightly paler than the dorsum; trochanters and base of femora rusty yellow, remaining segments of legs dark brown.

Penis: Corpus penis 3.24 mm long, 0.17 wide at the middle, 0.35 wide at the base, glans penis 0.28 long, 0.06 wide, distal tube of glans 0.70 long. Corpus penis flatten dorso-ventrally, alate.

Female

Larger than the male and the body nearly ellipsoid (Fig. 25), fully matured female with eggs oval. Palpus differs greatly from the male; femur from above slightly thickened distally, from the side very lightly arched above, covered with light hairs, in some, armed with a few denticles at distal end above and lateral, patella (Fig. 3) widened distally, the disto-mesal angle produced into a distinct long apophysis, hairy densely, no armaments, tibia from the side nearly straight below; the disto-mesal angle produced into a blunt lobe representing apophysis, which densely covered with hairs, tarsus slender, nearly straight, not armed ventro-mesally with a narrow band of small, black denticles.

Coloration, in some, similar to the male, but others show more distinct color, i.e. dorsum silvery white with dark brownish markings, margins of carapace and scutum rusty yellow to light brown. Markings generally equal to the male, median band of abdomen dark brown, contrasting to the silvery white ground. Venter rusty yellow to light yellow. Palpus, in some, rusty yellow, in others, patella, femur, tibia dark brown. Chelicera and legs similar to the male in color.

Measurements (in mm.)

Male.

Total length of body : 4.2-5.0 (average 4.5).

Width of abdomen : 2.1-2.4 (average 2.3).

Legs :

		Min.	Max.	Average			Min.	Max.	Average
Length of femur	I	6.6	7.8	7.2		I	30.5	38.0	34.7
	II	11.1	14.5	12.9	Total length	II	62.0	77.0	70.3
	III	6.0	7.2	6.8		III	31.5	39.8	36.1
	IV.	8.4	10.1	9.4		IV	42.3	55.0	49.7

Palpus :

	Length			Width		
	Min.	Max.	Average	Min.	Max.	Average
Troch.	0.34	0.40	0.36	0.27	0.30	0.29
Fem.	0.95	1.15	1.10	0.26	0.30	0.29
Pat.	0.60	0.70	0.68	0.25	0.30	0.28
Tib.	0.75	0.90	0.83	0.23	0.28	0.25
Tars.	1.15	1.30	1.22	0.10	0.14	0.13
Total	3.90	4.40	4.19			

Female.

Total length of body : 5.5-6.1 (average 5.8).

Width of abdomen : 3.1-3.5 (average 3.3).

Legs :

		Min.	Max.	Average			Min.	Max.	Average
Length of femur	I	6.0	7.4	6.7		I	28.0	32.8	30.5
	II	10.6	13.0	11.9	Total length	II	60.3	67.9	65.0
	III	8.1	6.9	6.5		III	30.1	33.3	31.6
	IV	8.0	9.6	8.9		IV	41.8	48.8	45.4

Length of palpus : Trochanter 0.3-0.4 (average 0.37); femur 1.05-1.15 (average 1.12); patella 0.50-0.60 (average 0.56); tibia 0.70-0.80 (average 0.78); tarsus 1.40-1.50 (average 1.44); total length 4.20-4.35 (average 4.27).

Types : Holotype male and allotype female, Mt. Bushu-mitake, Tokyo Pref., 8. Sept. 1956. 2 male, 2 female paratypes, the same locality, 19. Aug. 1947; 12 males, 6 females, 1-2. Aug. 1955; 35 males, 16 females, the same locality, 8-9. Sept. 1956. These animals were collected by S. Suzuki and are deposited in the Zoological Laboratory, Hiroshima University.

Remarks : As stated above, the present species is very closely allied to *L. curvipalpi* Roewer and *L. hiraiwai* (Sato et Suzuki), but is clearly distinguishable from them by palpus, penis and chromosomes.

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